Creating Triggers

Objectives

After completing this lesson, you should be able to do the following:

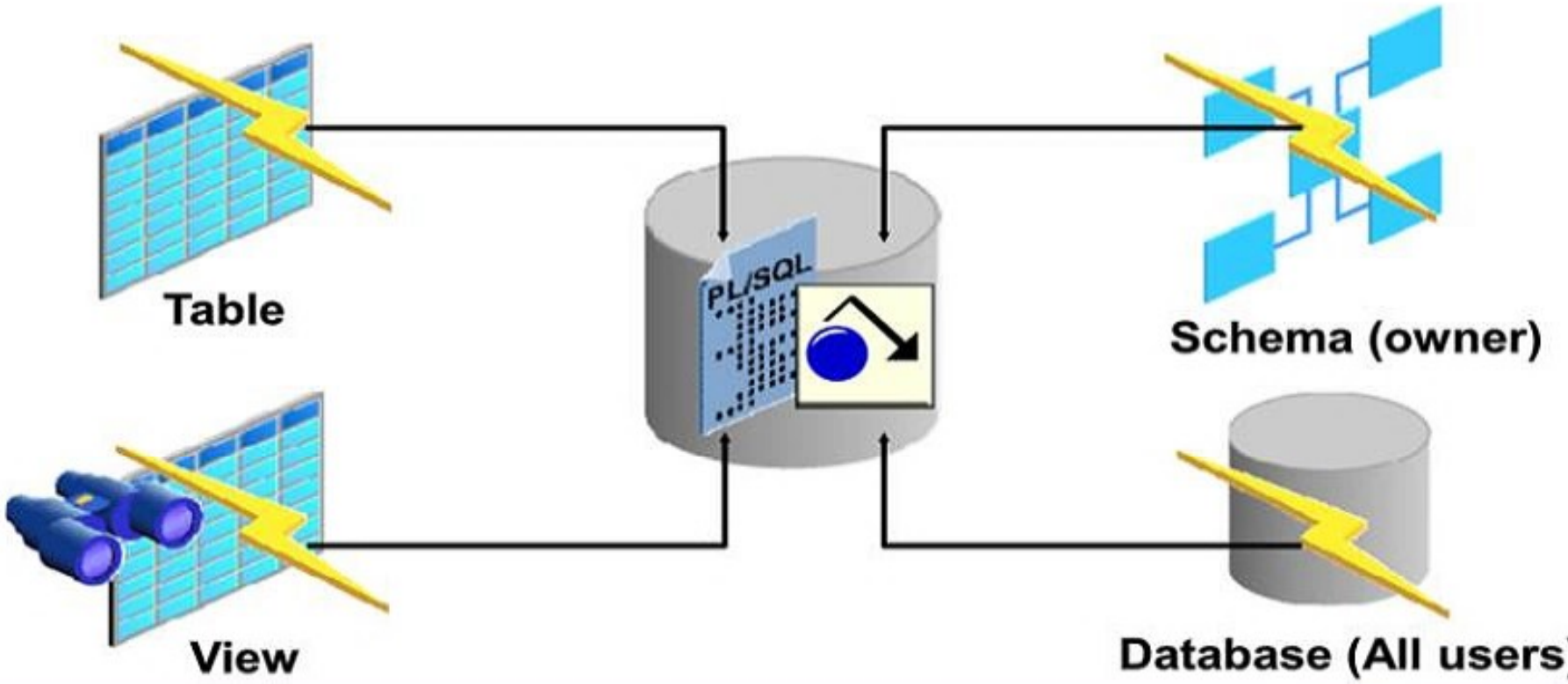
- Describe database triggers and their uses
- Describe the different types of triggers
- Create database triggers
- Describe database trigger-firing rules
- Remove database triggers
- Display trigger information

What Are Triggers?

- A trigger is a PL/SQL block that is stored in the database and fired (executed) in response to a specified event.
- The Oracle database automatically executes a trigger when specified conditions occur.

Defining Triggers

A trigger can be defined on the table, view, schema (schema owner), or database (all users).



Trigger Event Types

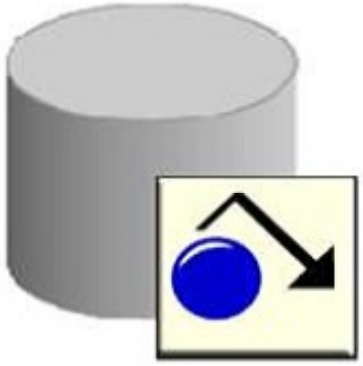
You can write triggers that fire whenever one of the following operations occurs in the database:

- A database manipulation (DML) statement (`DELETE`, `INSERT`, or `UPDATE`).
- A database definition (DDL) statement (`CREATE`, `ALTER`, or `DROP`).
- A database operation such as `SERVERERROR`, `LOGON`, `LOGOFF`, `STARTUP`, or `SHUTDOWN`.

Application and Database Triggers

- Database trigger (covered in this course):
  - Fires whenever a DML, a DLL, or system event occurs on a schema or database
- Application trigger:
  - Fires whenever an event occurs within a particular application

Application Trigger



Database Trigger

Business Application Scenarios for Implementing Triggers

You can use triggers for:

- Security
- Auditing
- Data integrity
- Referential integrity
- Table replication
- Computing derived data automatically
- Event logging

Available Trigger Types

- Simple DML triggers
  - BEFORE
  - AFTER
  - INSTEAD OF
- Compound triggers
- Non-DML triggers
  - DDL event triggers
  - Database event triggers

Trigger Event Types and Body

- A trigger event type determines which DML statement causes the trigger to execute. The possible events are:
  - `INSERT`
  - `UPDATE [OF column]`
  - `DELETE`
- A trigger body determines what action is performed and is a PL/SQL block or a `CALL` to a procedure

Creating DML Triggers Using the CREATE TRIGGER Statement

```
CREATE [OR REPLACE] TRIGGER trigger_name
timing -- when to fire the trigger
event1 [OR event2 OR event3]
ON object_name
[REFERENCING OLD AS old | NEW AS new]
FOR EACH ROW -- default is statement level trigger
WHEN (condition)]]
DECLARE]
BEGIN
... trigger_body -- executable statements
[EXCEPTION . . .]
END [trigger_name];
```

```
timing =  BEFORE | AFTER | INSTEAD OF
```

```
event = INSERT | DELETE | UPDATE | UPDATE OF column_list
```

Specifying the Trigger Firing (Timing)

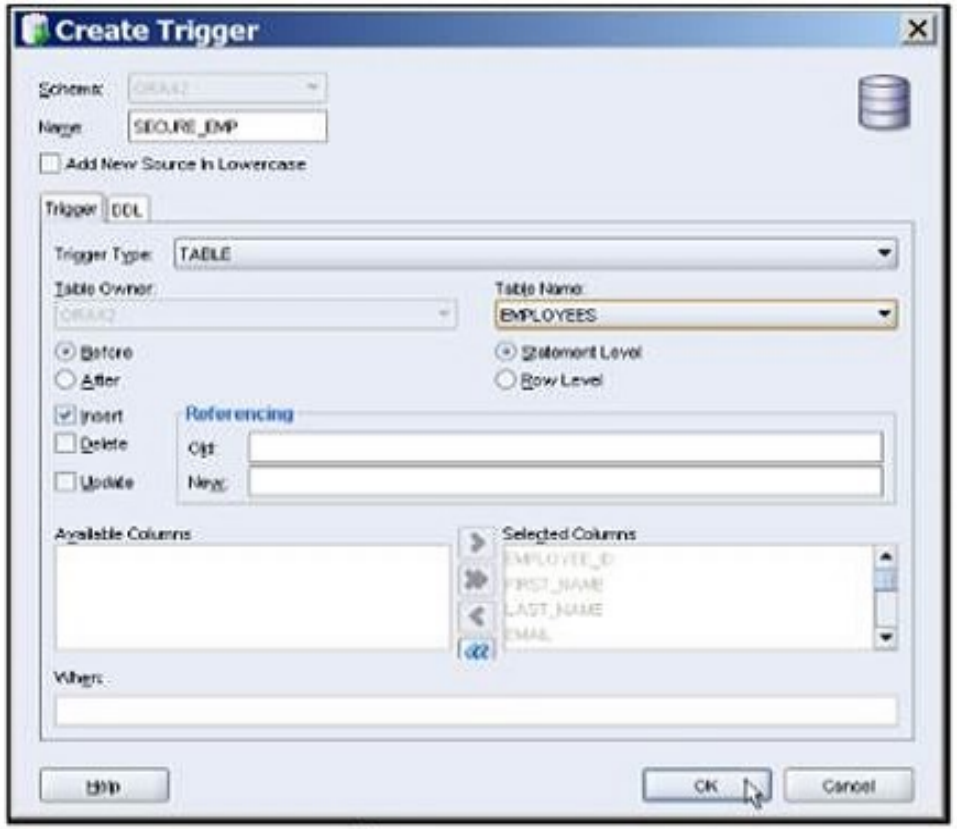
You can specify the trigger timing as to whether to run the trigger's action before or after the triggering statement:

- `BEFORE`: Executes the trigger body before the triggering DML event on a table.
- `AFTER`: Execute the trigger body after the triggering DML event on a table.
- `INSTEAD OF`: Execute the trigger body instead of the triggering statement. This is used for views that are not otherwise modifiable.

Statement-Level Triggers Versus Row-Level Triggers

Statement-Level Triggers	Row-Level Triggers
Is the default when creating a trigger	Use the `FOR EACH ROW` clause when creating a trigger.
Fires once for the triggering event	Fires once for each row affected by the triggering event
Fires once even if no rows are affected	Does not fire if the triggering event does not affect any rows

Creating DML Triggers Using SQL Developer

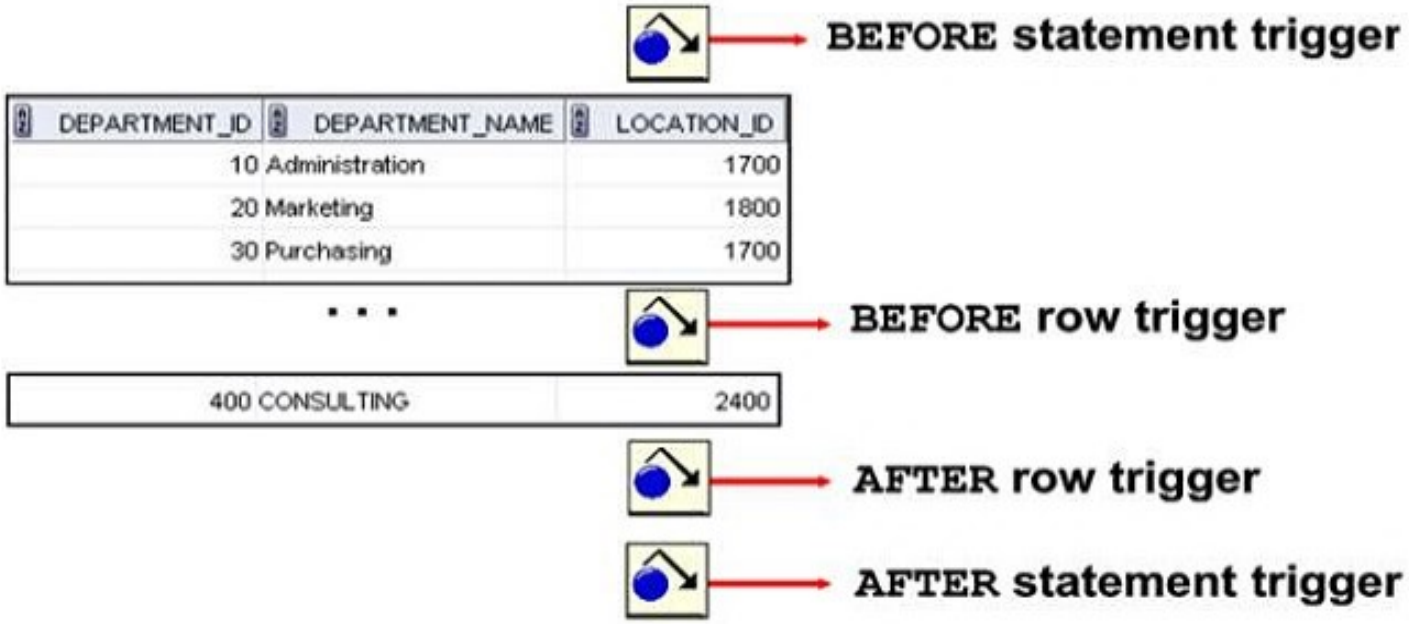



```
CREATE OR REPLACE TRIGGER secure_emp
BEFORE INSERT ON employees BEGIN
 IF (TO_CHAR(SYSDATE,'DY') IN ('SAT','SUN')) OR
     (TO_CHAR(SYSDATE,'HH24:MI') NOT BETWEEN '08:00' AND '18:00') THEN
  RAISE_APPLICATION_ERROR(-20500, 'You may insert' ||
  ' into EMPLOYEES table only during ' ||' business hours.');
  END IF;
END;
```

Trigger-Firing Sequence: Single-Row Manipulation

Use the following firing sequence for a trigger on a table when a single row is manipulated:

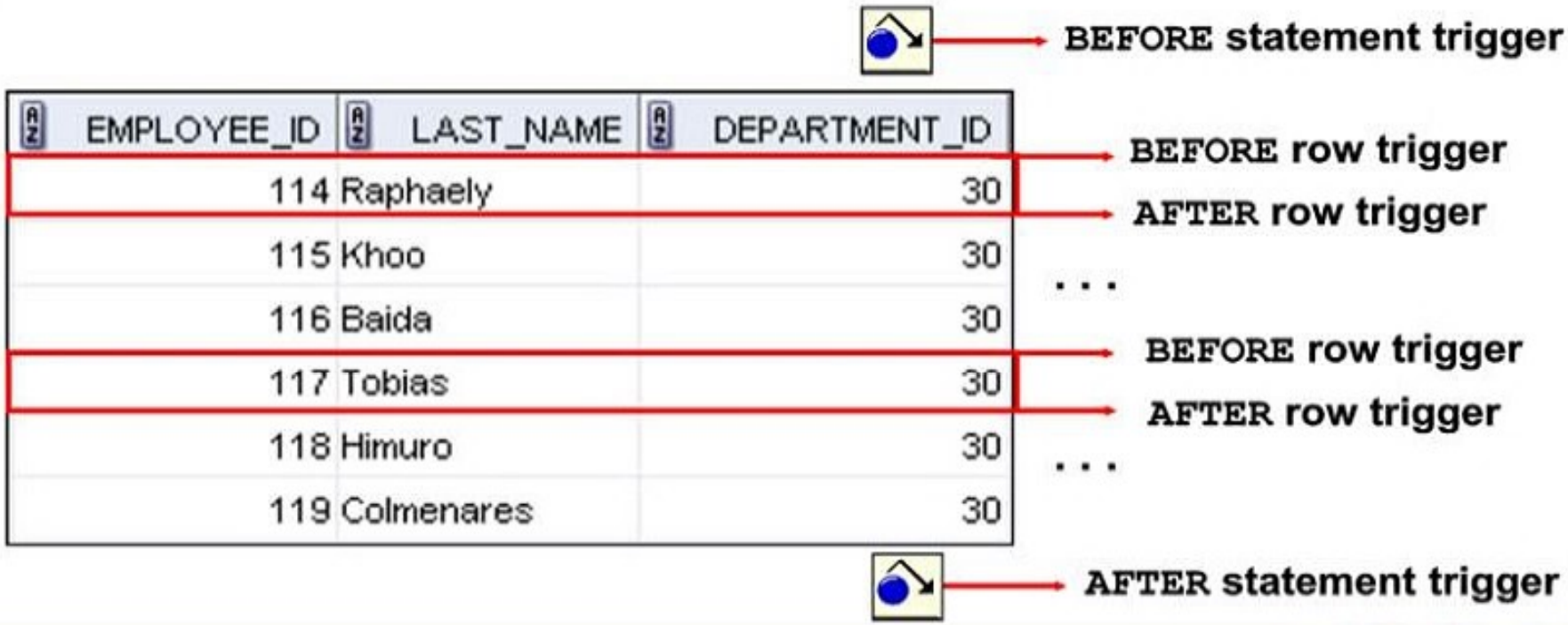
```
INSERT INTO departments
    (department_id,department_name, location_id)
VALUES (400, 'CONSULTING', 2400);
```



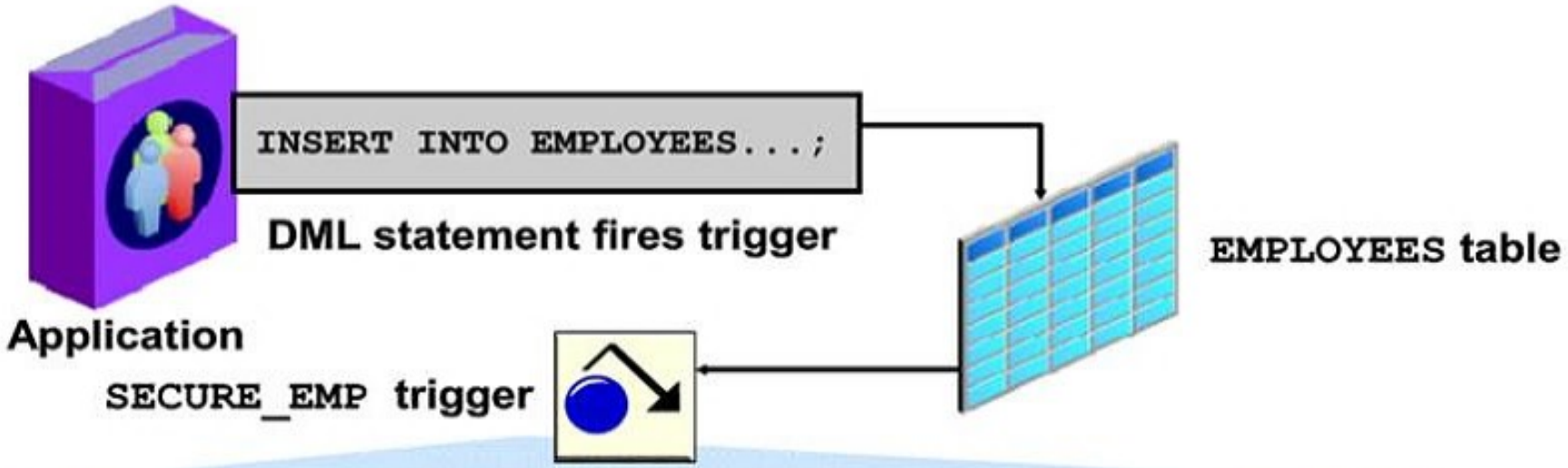
Trigger-Firing Sequence: Multirow Manipulation

Use the following firing sequence for a trigger on a table when many rows are manipulated:

```
UPDATE employees
  SET salary = salary * 1.1
  WHERE department_id = 30;
```



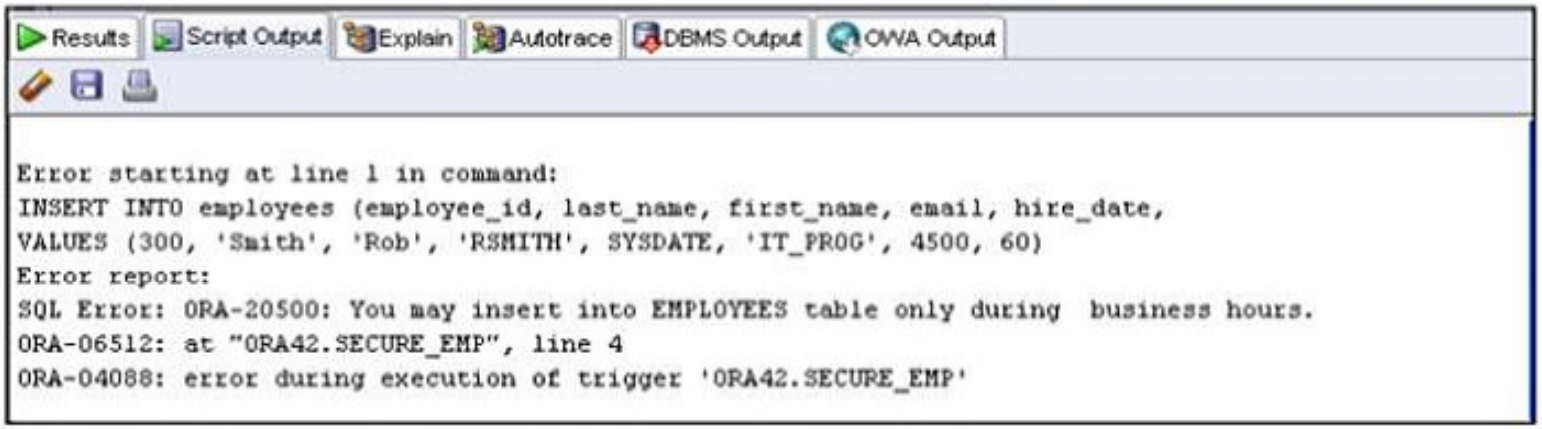
Creating a DML Statement Trigger Example: SECURE_EMP




```
CREATE OR REPLACE TRIGGER secure_emp
BEFORE INSERT ON employees
  BEGIN
   IF (TO_CHAR(SYSDATE,'DY') IN ('SAT','SUN')) OR
      (TO_CHAR(SYSDATE,'HH24:MI')
      NOT BETWEEN '08:00' AND '18:00') THEN
   RAISE_APPLICATION_ERROR(-20500, 'You may insert'
     ||' into EMPLOYEES table only during '
     ||' normal business hours.');
   END IF;
  END;
```

Testing Trigger SECURE_EMP

```
INSERT INTO employees (employee_id, last_name,
    first_name, email, hire_date,
job_id, salary, department_id)
VALUES (300, 'Smith', 'Rob', 'RSMITH', SYSDATE,
  'IT_PROG', 4500, 60);
```



Using Conditional Predicates

```
CREATE OR REPLACE TRIGGER secure_emp BEFORE
INSERT OR UPDATE OR DELETE ON employees
  BEGIN
    IF (TO_CHAR(SYSDATE,'DY') IN ('SAT','SUN')) OR
       (TO_CHAR(SYSDATE,'HH24')
        NOT BETWEEN '08' AND '18') THEN
     IF DELETING THEN RAISE_APPLICATION_ERROR(
        -20502,'You may delete from EMPLOYEES table'||
        'only during normal business hours.');
     ELSIF INSERTING  THEN RAISE_APPLICATION_ERROR(
        -20500,'You may insert into EMPLOYEES table'||
        'only during normal business hours.');
     ELSIF UPDATING  ('SALARY') THEN
        RAISE_APPLICATION_ERROR(-20503, 'You may '||
        'update SALARY only normal during business hours.');
      ELSE RAISE_APPLICATION_ERROR(-20504,'You may'||
        ' update EMPLOYEES table only during'||
        ' normal business hours.');
      END IF;
    END IF;
  END;
```

Creating a DML Row Trigger

```
CREATE OR REPLACE TRIGGER restrict_salary
BEFORE INSERT OR UPDATE OF salary ON employees
FOR EACH ROW
BEGIN
  IF NOT (:NEW.job_id IN ('AD_PRES', 'AD_VP'))
     AND :NEW.salary > 15000 THEN
    RAISE_APPLICATION_ERROR (-20202,
      'Employee cannot earn more than $15,000.');
  END IF;
END;/
```

```
UPDATE employees
SET salary = 15500
WHERE last_name = 'Russell';
```

```
Error starting at line 1 in command:
UPDATE employees
SET salary = 15500
WHERE last_name = 'Russell'
Error report:
SQL Error: ORA-20202: Employee cannot earn more than $15,000.
ORA-06512: at "ORA62.RESTRICT_SALARY", line 4
ORA-04088: error during execution of trigger 'ORA62.RESTRICT_SALARY'
```

Using OLD and NEW Qualifiers

- When a row-level trigger fires, the PL/SQL run-time engine creates and populates two data structures:
  - OLD: Stores the original values of the record processed by the trigger
  - NEW: Contains the new values
- NEW and OLD have the same structure as a record declared using the %ROWTYPE on the table to which the trigger is attached.

Data Operations	Old Value	New Value
INSERT	NULL	Inserted value
UPDATE	Value before update	Value after update
DELETE	Value before delete	NULL

Using OLD and NEW Qualifiers: Example

```
CREATE OR REPLACE TRIGGER audit_emp_values
AFTER DELETE OR INSERT OR UPDATE ON employees
FOR EACH ROW
BEGIN
  INSERT INTO audit_emp(user_name, time_stamp, id,
    old_last_name, new_last_name, old_title,
    new_title, old_salary, new_salary)
  VALUES (USER, SYSDATE, :OLD.employee_id,
    :OLD.last_name, :NEW.last_name, :OLD.job_id,
    :NEW.job_id, :OLD.salary, :NEW.salary);
END;
/
```

Using OLD and NEW Qualifiers: Example Using AUDIT_EMP

```
INSERT INTO employees (employee_id, last_name, job_id,
salary, email, hire_date)
VALUES (999, 'Temp emp', 'SA_REP', 6000, 'TEMPEMP',
TRUNC(SYSDATE));
/
UPDATE employees
 SET salary = 7000, last_name = 'Smith'
 WHERE employee_id = 999;
/
SELECT *
FROM  audit_emp;
```

	USER_NAME	TIME_STAMP	ID	OLD_LAST_NAME	NEW_LAST_NAME	OLD_TITLE	NEW_TITLE	OLD_SALARY	NEW_SALARY
1	ORA62	27-JUN-07	(null)	(null)	Temp emp	(null)	SA_REP	(null)	6000
2	ORA62	27-JUN-07	999	Temp emp	Smith	SA_REP	SA_REP	6000	7000

Using the WHEN Clause to Fire a Row Trigger Based on a Condition

```
CREATE OR REPLACE TRIGGER derive_commission_pct
BEFORE INSERT OR UPDATE OF salary ON employees
FOR EACH ROW
WHEN (NEW.job_id = 'SA_REP')
BEGIN
 IF INSERTING THEN
    :NEW.commission_pct := 0;
 ELSIF :OLD.commission_pct IS NULL THEN
    :NEW.commission_pct := 0;
 ELSE
    :NEW.commission_pct := :OLD.commission_pct+0.05;
 END IF;
END;
/
```

Summary of the Trigger Execution Model

1. Execute all `BEFORE STATEMENT` triggers.
2. Loop *for each row* affected by the SQL statement:
   a. Execute all `BEFORE ROW` triggers *for that row*.
   b. Execute the DML statement and perform integrity constraint checking *for that row*.
   c. Execute all `AFTER ROW` triggers *for that row*.
3. Execute all `AFTER STATEMENT` triggers.

Implementing an Integrity Constraint with an After Trigger

```
-- Integrity constraint violation error -2992 raised.
UPDATE employees SET department_id = 999
 WHERE employee_id = 170;
```

```
CREATE OR REPLACE TRIGGER employee_dept_fk_trg
AFTER UPDATE OF department_id
    ON employees FOR EACH ROW
BEGIN
 INSERT INTO departments VALUES(:new.department_id,
              'Dept '||:new.department_id, NULL, NULL);
EXCEPTION
   WHEN DUP_VAL_ON_INDEX THEN
    NULL; -- mask exception if department exists
END; /
```

```
-- Successful after trigger is fired
UPDATE employees SET department_id = 999
 WHERE employee_id = 170;
```

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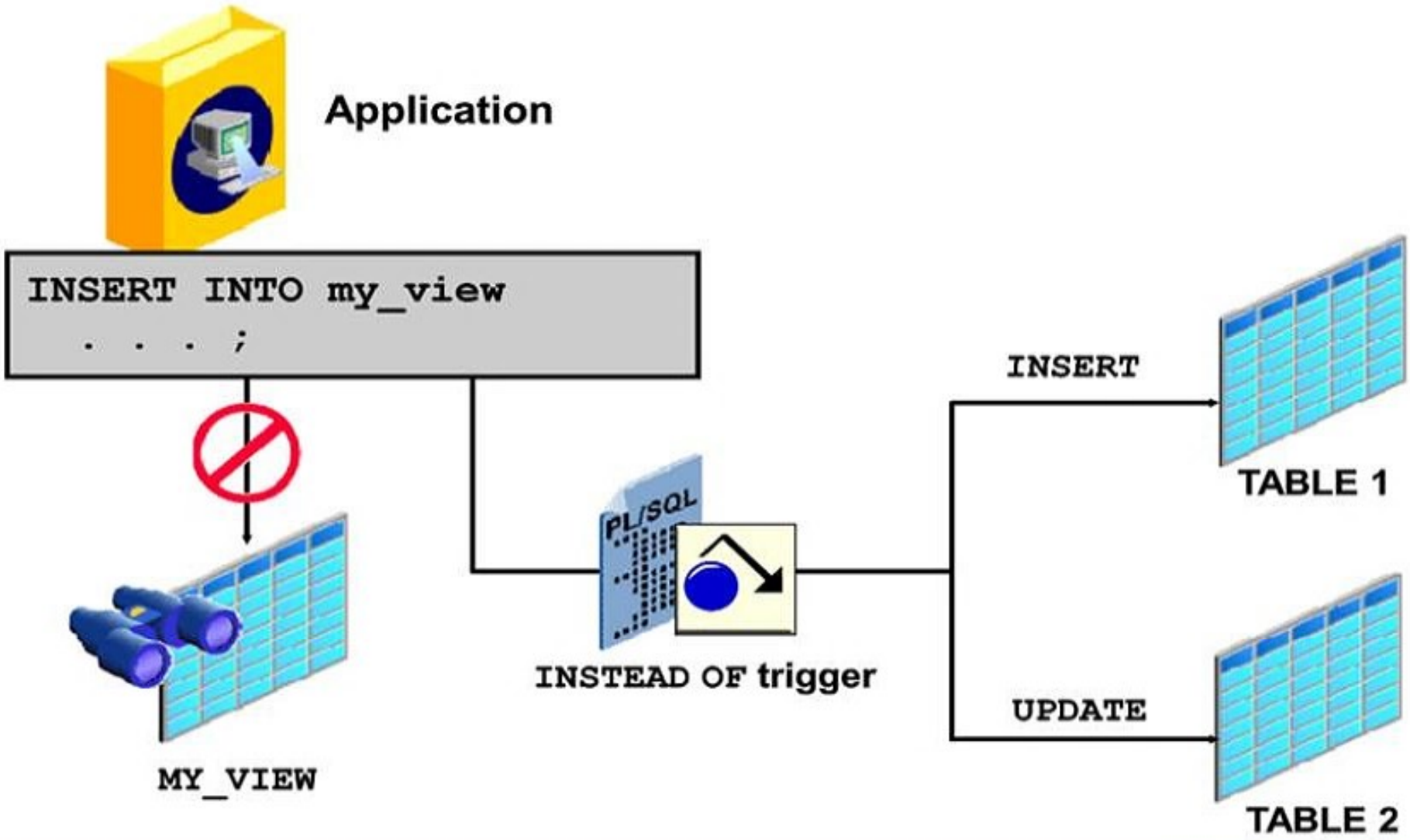
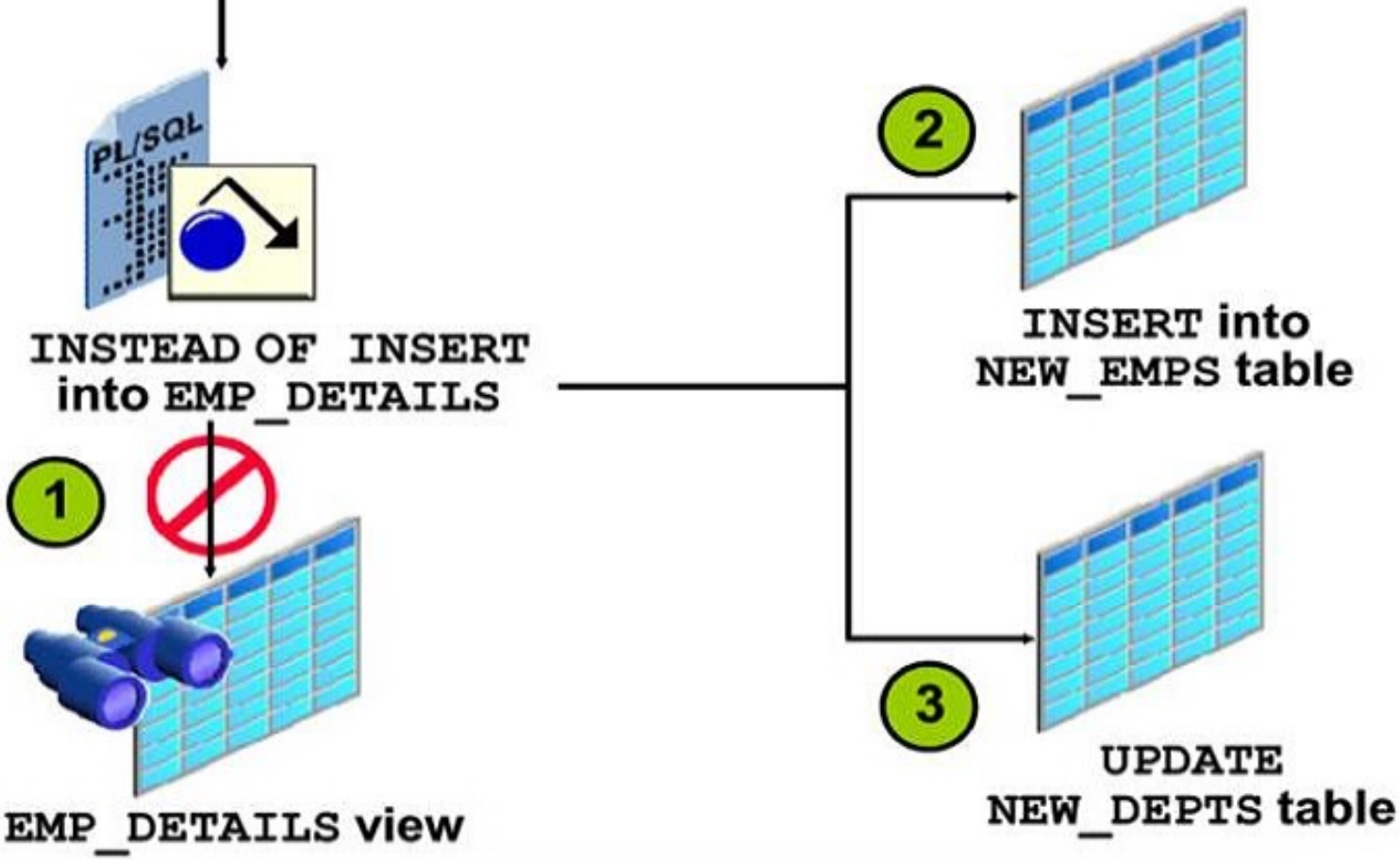
INSTEAD OF Triggers



Creating an INSTEAD OF Trigger: Example

```
INSERT INTO emp_details
VALUES (9001,'ABBOTT',3000, 10, 'Administration');
```



Creating an INSTEAD OF Trigger to Perform DML on Complex Views

```
CREATE TABLE new_emps AS
 SELECT employee_id,last_name,salary,department_id
     FROM employees;

CREATE TABLE new_depts AS
 SELECT d.department_id,d.department_name,
        sum(e.salary) dept_sal
     FROM employees e, departments d
 WHERE e.department_id = d.department_id;

CREATE VIEW emp_details AS
 SELECT e.employee_id, e.last_name, e.salary,
        e.department_id, d.department_name
 FROM employees e, departments d
 WHERE e.department_id = d.department_id
GROUP BY d.department_id,d.department_name;
```

The Status of a Trigger

A trigger is in either of two distinct modes:

- Enabled: The trigger runs its trigger action if a triggering statement is issued and the trigger restriction (if any) evaluates to true (default).
- Disabled: The trigger does not run its trigger action, even if a triggering statement is issued and the trigger restriction (if any) would evaluate to true.

Creating a Disabled Trigger

- Before Oracle Database 11*g*, if you created a trigger whose body had a PL/SQL compilation error, then DML to the table failed.
- In Oracle Database 11*g*, you can create a disabled trigger and then enable it only when you know it will be compiled successfully.

```
CREATE OR REPLACE TRIGGER mytrg
  BEFORE INSERT ON mytable FOR EACH ROW
  DISABLE
BEGIN
  :New.ID := my_seq.Nextval;
. . .
END;
/
```

Managing Triggers Using the ALTER and DROP SQL Statements

```
-- Disable or reenable a database trigger:

ALTER TRIGGER trigger_name DISABLE | ENABLE;
```

```
-- Disable or reenable all triggers for a table:

ALTER TABLE table_name DISABLE | ENABLE ALL TRIGGERS;
```

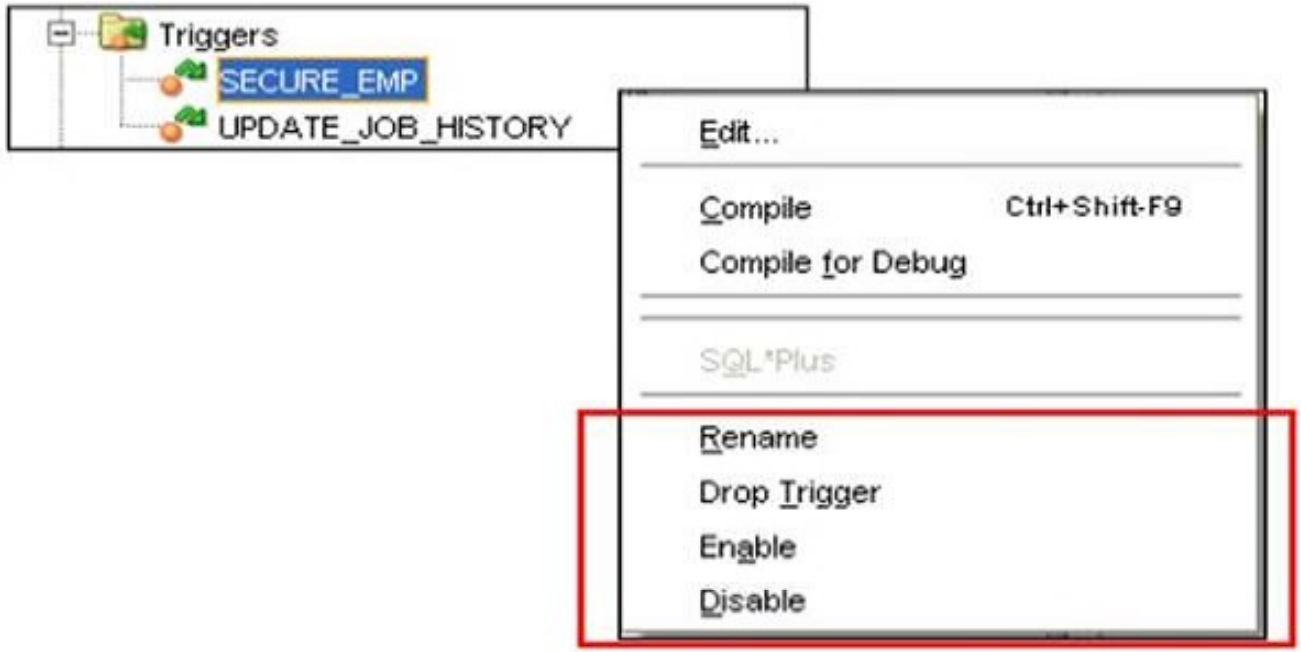
```
-- Recompile a trigger for a table:

ALTER TRIGGER trigger_name COMPILE;
```

```
-- Remove a trigger from the database:

DROP TRIGGER trigger_name;
```

Managing Triggers Using SQL Developer



Testing Triggers

- Test each triggering data operation, as well as non-triggering data operations.
- Test each case of the `WHEN` clause.
- Cause the trigger to fire directly from a basic data operation, as well as indirectly from a procedure.
- Test the effect of the trigger on other triggers.
- Test the effect of other triggers on the trigger.

Viewing Trigger Information

You can view the following trigger information:

Data Dictionary View	Description
USER_OBJECTS	Displays object information
USER/ALL/DBA_TRIGGERS	Displays trigger information
USER_ERRORS	Displays PL/SQL syntax errors for a trigger

Using USER_TRIGGERS

```
DESCRIBE user_triggers
```

```
Name                           Null     Type
------------------------------ -------- ----------------------------------------------------------------
TRIGGER_NAME                            VARCHAR2(30)
TRIGGER_TYPE                            VARCHAR2(16)
TRIGGERING_EVENT                        VARCHAR2(227)
TABLE_OWNER                             VARCHAR2(30)
BASE_OBJECT_TYPE                        VARCHAR2(16)
TABLE_NAME                              VARCHAR2(30)
COLUMN_NAME                             VARCHAR2(4000)
REFERENCING_NAMES                       VARCHAR2(128)
WHEN_CLAUSE                             VARCHAR2(4000)
STATUS                                  VARCHAR2(8)
DESCRIPTION                             VARCHAR2(4000)
ACTION_TYPE                             VARCHAR2(11)
TRIGGER_BODY                            LONG()
CROSSEDITION                            VARCHAR2(7)

14 rows selected
```

```
SELECT trigger_type, trigger_body
FROM user_triggers
WHERE trigger_name = 'SECURE_EMP';
```

Quiz

A triggering event can be one or more of the following:

1. An `INSERT`, `UPDATE`, or `DELETE` statement on a specific table (or view, in some cases)
2. A `CREATE`, `ALTER`, or `DROP` statement on any schema object
3. A database startup or instance shutdown
4. A specific error message or any error message
5. A user logon or logoff

Summary

In this lesson, you should have learned how to:

- Create database triggers that are invoked by DML operations
- Create statement and row trigger types
- Use database trigger-firing rules
- Enable, disable, and manage database triggers
- Develop a strategy for testing triggers
- Remove database triggers

Practice 9 Overview: Creating Statement and Row Triggers

This practice covers the following topics:

- Creating row triggers
- Creating a statement trigger
- Calling procedures from a trigger